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IONS, ELECTRONS, AND CORPUSCLES.

Les Quantités élémentaires d'Électricité: Ions, Électrons, Corpuscles. Mémoires réunis et publiés par Henri Abraham et Paul Langevin. Two volumes. Pp. xvi+1138. (Paris: Gauthier-Villars et Fils, 1905.) Price 35 francs.

THIS very important work, which has been brought out by the French Physical Society under the joint editorship of MM. Abraham and Langevin, consists of a series of digests of the memoirs on which the foundation of the electrodynamic theory of matter is laid. In some cases *résumés* of their researches have been written especially for this work by the original authors, but in the majority of instances the papers have been dealt with by abstractors. The value of this method depends entirely on the insight which is brought to bear upon it, and the task must have been particularly difficult in the present instance owing to the great variety of the material concerned, since many of the investigations are purely experimental, whilst others require all the skill in abstract reasoning possessed by the pure mathematician. The excellence which we should expect from the names of the editors, one of whom, M. Langevin, has himself made extensive and valuable contributions to the subject, is completely justified by the result. Whenever it was consistent with the necessary brevity, the abstractors have kept to the original words of the author, and, so far as the reviewer has been able to discover, no author can claim that his views have been misrepresented in any important particular.

The book will be heartily welcomed by all who are interested in the development of the electron theory, whether it be in its most general aspect as a fundamental theory of physical phenomena or in its extremely interesting applications to such complex branches of the subject as the conduction of electricity through gases and radio-activity. It is true that we have a number of books, such as J. J. Thomson's "Conduction of Electricity through Gases" and "Electricity and Matter," Larmor's "Æther and Matter," Poincaré's "Électricité et Optique," Stark's "Die Electrizztät in Gasen," and Rutherford's "Radio-activity," which in one way or another contain the whole of the material of the two volumes under review; but in these cases the material has usually been selected, often, of course, with gain of interest, so as to emphasise the point of view of the particular author. In the present work, on the contrary, we are furnished with an account of each portion of the subject as it developed itself in the mind of its discoverer. The work therefore fills a distinct lacuna in the literature of the subject.

Recent advances in electrodynamics have placed the fundamental principles of physics in an interesting but not altogether satisfactory position. By considering the energy of the electric field, J. J. Thomson showed, many years ago, that a moving electric charge possessed a spurious mass due to the distur-

ance it created in the ether through which it was moving. This idea has been more than confirmed by the experiments of Kaufmann on the mass of the Becquerel rays or negative electrons. These experiments show that the *whole* of the mass of these electrons is of electrical origin, and is due entirely to the motion of their electric charges. The work of Lorentz and Larmor has given very good reasons for supposing that all matter consists solely of electrons, so that we are forced to the conclusion that the mass of all matter is due to the electrical charges of its ultimate particles.

The reasoning by which this result has been arrived at is dynamical in character, and is therefore based on mass, space, and time as fundamental conceptions. Thus, by the application of a system of thought in which mass is a fundamental conception, we have succeeded in resolving the idea of mass into something, viz. electricity, which lies outside the system.

There appear to be two ways of escape from the confusion implied by this paradoxical result. The first is to resolve electricity into the mass motion of a mechanical ether, and thus to make everything again consistent with the fundamental laws of mechanics. Attempts to construct a dynamical theory of the ether have continually been made ever since the ether began to figure in the literature of exact science. The most successful hitherto has been that of Larmor, which made the ether a perfect fluid composed of gyrostatic atoms. According to this view, which has been criticised by Poincaré in his "Électricité et Optique," the velocity of the ether is along the lines of magnetic force. We have, however, good grounds for thinking that the drift velocity of the ether is proportional to the vector product of the electric and magnetic forces, and it is probable that the successful ether theory will furnish an explanation of this result.

The second way of escape is to take the equations of the electromagnetic field as ultimate relations which are empirically given and of which there is no "explanation." By making energy the fundamental conception, we could then obtain a consistent scheme which would not involve the idea of mass in any fundamental way. The equations of motion of any material system could then be obtained by an appropriate variation of the energy function, which of course contains only electric and magnetic terms, and the results expressed in terms of force subsequently if required. On this view the momentum in any system is obtained as the volume integral of the vector product of the electric and magnetic forces, and mass is simply the vector coefficient which results on dividing the increase in this by the corresponding increase in velocity. This method of stating the case, which makes mass a very secondary conception, will at once be recognised as our old friend the "energetic" view of things, and the electrodynamic explanation of mass may justly be regarded as a great triumph for energetics. The considerations which have been brought forward in the preceding paragraph show, however, that the solution in terms of

energy is not the only solution of the problem, and it remains for the future to decide which of the two is the more convenient and the more fundamental. The "energetic" system of physical philosophy suffers by being intangible and lacking in imaginative stimulus, whilst the material it makes use of in order to build up a picture of the phenomena of nature is not characterised by the simplicity which is desirable in relations of so ultimate a character.

Returning to the book under review, we find, naturally, that a great deal of it refers to the important investigations on the charge, mass, velocity, and other properties of ions and electrons. These have been described with that excellence which characterises the whole production. The reader will find a particularly satisfactory account of Townsend's very exact investigations on ionisation by collisions.

There is a minor point which may be criticised, and that is the prominence given to Moreau's results on the velocity of ions produced by metallic salts in flames. That investigator found that the velocity of the negative ions varied in an unexplained way with the concentration of the salt and the atomic weight of the metal, whereas H. A. Wilson found it to be independent of both these factors. The editors appear to have overlooked the experiments on this subject of the last-named author.

With this slight exception, we have nothing but praise for the whole work, and heartily congratulate the French Physical Society and all who have been concerned in its production. We hope that they will be able to bring out more volumes of a like kind as the development of the subject proceeds. It will be remembered that a few years ago the French Physical Society published a very important series of memoirs, on all branches of physics, which had been communicated to the International Congress at Paris in 1900. The extraordinary activity of the society in this way must command the admiration and gratitude of physicists in every part of the world.

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ANOTHER PLEA FOR RATIONAL EDUCATION.

On Professional Education, with Special Reference to Medicine. An Address delivered at King's College, London, on October 3, 1905. By Prof. T. Clifford Allbutt, F.R.S. Pp. vi+80. (London: Macmillan and Co., Ltd., 1906.) Price 2s. net.

"THERE is no state so perilous as that in which things seem good to us, and at present in England the schoolmaster is complacent, the public indifferent." So Prof. Allbutt generalises early in his address, directing attention, however, in a footnote, to a single exception in the case of the headmaster of the Perse School, Cambridge. Though many more earnest schoolmasters anxious to reform scholastic methods could be named, thoughtful observers of English educational procedure must admit—in spite of the current bickerings among politicians as to religious instruction in elementary schools—that the schoolmaster's policy of *laissez-aller* and the apathy

of the public are, and have been, the chief causes of the chaotic and rudimentary state of our secondary education. For half a century it has been dinned into the ears of statesmen, parents, and schoolmasters that no system of higher education, whether academic or technical, can prove successful in the absence of a sane, modern, and broad supply of secondary education given by rationally trained teachers. Prof. Allbutt is to be congratulated upon ranging himself on the side of the prophets, and though for the present he may be a voice crying in the wilderness, his able advocacy of the introduction of sweet reasonableness into our secondary schools will some day be counted unto him for righteousness.

A few of Prof. Allbutt's lessons to the schoolmaster may be quoted with advantage: "The scientific study of facts is the lever by which liberal culture has been re-awakened, and we are beginning to see that the ideas and methods of natural science, instead of being merely curious or commercial, are, if not the flower of education, at any rate the stem and branches." "On both 'sides' [of most schools], while the memory is exercised, and the intellect somewhat called upon, the imagination, the centre of creative life, the source of great action, is left out in the cold." The teacher who fears the baneful effects of specialisation may note this:—"I am satisfied that if the two main coefficients of mind—the intellect and the imagination—are fostered, it proves best in the end to promote development in each person on the lines of his own nature." But we have kept what in our judgment is the most important quotation—trite though the advice is—to the last:—"It is not so much *what* a man is taught as *how* he is taught it."

This advice leads naturally to the consideration of the present secondary school curriculum. Not every essential part of a wide subject can be included in a single address, but it is to be regretted that Prof. Allbutt has so little to say on the simplification and lightening of the absurdly congested time-tables of most schools. It is true that we are told that the current teaching of Greek and Latin is a parody of education, and that, like Sir William Ramsay, Dr. Allbutt considers chemistry is not a good subject for boys, but some guidance in the direction of a ruthless cutting down of the number of subjects at present studied by young boys would have been welcome. It is in this direction that the schoolmaster has a right to look to the man of science for guidance. Cannot physiologists and psychologists agree together as to what groups of faculties should be trained during the years of school-life, and, with the help of pedagogical experts, decide which groups of subjects best assist such training? Until this is done, or until some masterful genius filled with the pedagogic passion arises who will solve this most pressing of educational problems, secondary education will continue to be a process of filling the minds of boys and girls with pellets of information in a multitude of subjects, and of loading the verbal memory with a brecciated congeries of unrelated facts.

On the tertiary, or university, stage of education